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Cigarette Smoking During Recovery From Substance Use Disorders

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IMPORTANCE Cigarette smoking is more prevalent among those with than without other substance use disorders (SUDs). However, smoking cessation interventions are often absent from SUD treatment facilities.

OBJECTIVES To inform smoking cessation and SUD care by assessing smoking status and SUD recovery over time to determine whether transitioning from current to former smoking is associated with sustained SUD recovery.

DESIGN, SETTING, AND PARTICIPANTS This cohort study was conducted among a nationally representative cohort of US adults with history of SUD from the PATH (Population Assessment of Tobacco and Health) Study. The PATH Study is an ongoing, nationally representative, longitudinal cohort study in the US. Analyses included adults (aged ≥18 years) in the wave 1 cohort (recruited in 2013/2014) assessed annually over 4 years until wave 4 (2016/2018). A second nationally representative cohort (from 2016/2018 to 2023) was also assessed in sensitivity analyses. Data analysis was completed from June 2024 to September 2024.

EXPOSURE Cigarette smoking (never, former, and current use).

MAIN OUTCOMES AND MEASURES The primary outcome was SUD recovery, assessed via the Global Appraisal of Individual Needs–Short Screener SUD subscale, measured as high lifetime SUD symptoms (4-7 symptoms) and zero past-year symptoms (sustained remission) or high lifetime SUD symptoms with any past-year symptoms (current substance use or SUD). Fixed-effects logistic regression assessed within-person change in smoking and its association with SUD recovery, accounting for between-person confounders.

RESULTS Among 2652 adults from 2013/2014 to 2016/2018, 41.9% of participants (95% CI, 39.4%-44.4%) were female, and mean age was 39.4 years (95% CI, 38.7-40.3). By self-reported race and ethnicity, 17.0% of participants (95% CI, 15.3%-18.9%) were Hispanic, 13.9% (95% CI, 12.2%-15.6%) were non-Hispanic Black, 63.1% (95% CI, 60.4%-65.7%) were non-Hispanic White, and 6.0% (95% CI, 4.9%-7.4%) were another non-Hispanic race (Asian, Native American/Alaska Native, Native Hawaiian/Other Pacific Islander, more than 1 race). Within-person change from current to former smoking was positively associated with SUD recovery: year-to-year change to former cigarette use was associated with a 30% increase in odds of recovery (odds ratio [OR], 1.30; 95% CI, 1.07-1.57), accounting for time-varying covariates and between-person differences. This association remained significant after lagging predictor by 1 year (OR, 1.43; 95% CI, 1.00-2.05) and in the second cohort assessed from 2016/2018 to 2022/2023 (OR, 1.37; 95% CI, 1.13-1.66).

CONCLUSIONS AND RELEVANCE In this cohort study, within-person change from current to former smoking was associated with recovery from other SUDs. These results suggest that smoking cessation could be used as a tool to assist recovery processes and improve health among adults with an SUD.

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Supplemental content

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Despite declines in cigarette smoking,[1] smoking remains the leading preventable cause of morbidity and mortality in the US. Disparities in smoking also persist[2,3]—certain subgroups smoke at disproportionately high rates,[4,5] particularly individuals with nontobacco substance use disorders (SUDs).[6-10] Individuals with SUDs also have a disproportionately high likelihood of dying from tobacco-related causes.[11,12] There are renewed calls to treat tobacco use, particularly smoking, among those with SUDs.[8] However, tobacco use is undertreated and often untreated in health facilities that treat SUDs,[13-18] as treatment professionals may consider smoking a low priority.[8,16] Recent estimates show there are 48.5 million people in the US with an SUD in the past 12 months,[19] and 35.8% of those with an SUD currently smoke,[6] making recovery from SUDs and smoking public health priorities.

Previous research shows that smoking cessation is associated with improved outcomes for SUDs.[20-23] However, most studies are from population samples with data collected at least 20 years ago or from treatment studies,[24,25] and few studies examine how change in smoking status is related to SUD recovery over time using recent, nationally representative samples. Research designs that can account for confounding factors (eg, randomized clinical trials that isolate the experimental effect of smoking on SUD recovery) are typically not feasible at the population level, but quantitative methods applied to population-based data can approximate experimental conditions that remove the influence of confounders across individuals.[26-32] Using nationally representative samples would provide estimates that are generalizable to millions of US adults with an SUD, including those who do and do not receive treatment,[32] and using methods that account for confounding factors across individuals would provide more accurate estimates of how change in cigarette smoking is associated with SUD recovery over time.[31,32]

The purpose of this study was to assess smoking and SUD recovery over time using data from the US nationally representative PATH (Population Assessment of Tobacco and Health) Study,[33-37] focusing on whether within-person transitions from current to former smoking were associated with SUD remission. Quantitative methods that account for measured and unmeasured factors across individuals were used, minimizing any impact of these confounding factors.[31] This study's primary research question was whether the transition from current to former smoking status increases sustained remission from SUD over time in a nationally representative sample followed annually over multiple years. Specifically, we tested whether odds of past 12-month SUD recovery increase in years when those with a history of SUD do not smoke relative to years when they smoke, accounting for differences across individuals that could influence the smoking-recovery association. Based on previous literature, we hypothesized that transitioning from current to former smoking would be associated with SUD recovery.

Key Points

Question Do changes in cigarette smoking predict substance use disorder (SUD) recovery over time, accounting for between-person confounders?

Findings In this longitudinal survey cohort study of 2652 participants, within-person transitions away from smoking were positively associated with SUD recovery in a nationally representative cohort; quitting smoking increased the odds of SUD recovery by 30% in fully adjusted models. Findings were robust in sensitivity analyses.

Meaning These results imply that quitting smoking is linked to better SUD recovery outcomes; smoking cessation could be a tool for assisting the recovery process among the millions of US adults with a current SUD.

Methods

Data came from the PATH Study, which is an ongoing, nationally representative, longitudinal cohort study of adults and youth in the US. The PATH Study consists of individuals selected at the inception wave and 2 later replenishment waves. The PATH Study used a stratified address-based, area-probability sampling design that oversampled adults who self-reported tobacco use, young adults, and adults who identify as Black or African American. Study participants recruited at baseline between September 2013 and December 2014 formed the wave 1 (W1) cohort. Our primary analyses assessed the W1 cohort annually across 4 waves until W4 (December 2016 to January 2018). Data for W2 and W3 were gathered from October 2014 to October 2015 and from October 2015 to October 2016, respectively. PATH Study restricted-use files were analyzed,[33] and analyses focused on adults aged 18 years and older. Among adults selected during initial screening, 32 320 interviews were conducted at W1 (74.0% weighted response rate). The weighted W4 response rate for the W1 cohort, conditional upon W1 participation, was 73.5%, representing 27 757 adult respondents. Youth who aged up into the adult PATH Study at each wave between W1 and W4 were included. Further details regarding the PATH Study design and methods and the reliability and validity of responses are published elsewhere.[34-37] Details on interview procedures, questionnaires, sampling, weighting, and response rates are described in the PATH Study restricted-use files user guide.[33] The study was conducted by Westat and approved by the Westat institutional review board. All respondents aged 18 years and older provided informed consent. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cohort studies.

At W4, the first probability replenishment sample was selected from the US civilian noninstitutionalized population at the time of W4. More details on this replenishment sample have been published elsewhere.[37] Sensitivity analyses were conducted that assessed this second nationally representative cohort from W4, which included 4 waves of data across the COVID-19 pandemic: W5 data were collected from December 2018 to November 2019; W6 from March 2021 to November 2021; and W7 from January 2022 to April 2023.

Primary Analytic Sample

Inclusion criteria for being in the analytic sample included (1) being in the W1 cohort; (2) having longitudinal (all-wave) weights;

(3) having an SUD in their lifetime (including both adults in SUD recovery and those with current SUD symptoms); (4) having 2 or more waves of adult data over the study period; (5) having a change in recovery status (described in Measures) over the study period; and (6) having no missing data. The analytic sample consisted of 2652 adult respondents. The samples across each wave were 1776, 2334, 2413, and 2565 respondents in waves 1 through 4, respectively. The analytic sample included 354 respondents with 2 waves (13.4%), 812 with 3 waves (30.6%), and 1486 with 4 waves of data (56.03%). eMethods 1 in the Supplement provides more details on the analytic sample, including those who were excluded because they had an SUD and did not change SUD recovery status during the study period and their smoking status.

Measures

SUD Recovery

A dichotomous recovery measure captured sustained remission from SUD symptoms, assessed via the Global Appraisal of Individual Needs–Short Screener (GAIN-SS) subscale for SUDs[38,39] (1 = sustained remission, 0 = current symptoms or substance use). Following past research,[38,39] sustained remission was measured as having high lifetime SUD symptoms (4-7 symptoms) but zero symptoms or use in the past 12 months, and current SUD or use was measured as having high lifetime SUD symptoms with any SUD symptom or use in the past 12 months.[38,39] The GAIN-SS measure is designed to measure annual change in recovery status via change in symptomology, akin to treatment outcomes of abstinence at 12 months postdischarge.[38] eMethods 2 in the Supplement provides wording for the GAIN-SS subscale for SUDs.

Cigarette Smoking

Cigarette smoking status was captured via a 3-level measure: never, former, and current. Former and current smoking included both experimental and established use. Current use (smoking some or all days in the past month) was used as the reference group.

Time-Varying Covariates

Time-varying covariates included mental health using the PROMIS Global Mental Health Subscale converted to T scores.[40] The subscale consisted of 4 items that assessed self-rated quality of life, mental health, satisfaction with social activities and relationships, and emotional problems. Each item ranged from 1 to 5, with high scores indicating better mental health. Other time-varying measures included educational attainment, which assessed highest level of education obtained via an ordinal measure (range: 1-4, with 1 = less than high school or GED, 2 = high school graduate, 3 = some college or associate degree, and 4 = bachelor degree or higher); medical treatment in the past 12 months based on whether respondents had seen a physician (1 = yes, 0 = no); and urgent care or emergency department visits in the past 12 months for a health problem (1 = yes, 0 = no). We also controlled for whether respondents used varenicline (Chantix) or bupropion (Wellbutrin, Zyban) in the past 12 months (1 = yes, 0 = no). Finally, a time-varying urban or rural location covariate was included, which was based on geocoded addresses and a 4-category measure derived from US National Center for Education Statistics classifications of urban, suburban, town, and rural locales.[33]

Analytic Strategy

We used fixed-effects logistic regression to test whether within-person, year-to-year change in smoking status was associated with SUD recovery over time. Fixed-effects regressions offer key advantages over conventional regressions, primarily in relation to omitted variable bias by removing potential effects of any time-invariant causes (measured or unmeasured),[31,41-44] similar to random assignment. Fixed-effects regressions remove effects of all time-invariant causes (all potential factors that could explain between-person differences in changes in SUD recovery over time, such as type of substances used at baseline or previous SUD treatment) at the person level and strictly examine within-person variance, allowing individual persons to serve as their own control by strictly making within-person comparisons over time.[31] Such methods are important for the current study because there are potential confounding factors across individuals that are difficult to measure or that do not change over time (eg, race, sex, genetic risk factors) in population-based surveys like the PATH Study. These potential confounding factors could affect changes in both smoking and SUD recovery.[32] Despite accounting for all differences across individuals, it is important to adjust for potential time-varying confounders in fixed-effects regression.[31,32] We adjusted for time-varying covariates previously mentioned. In our analysis, we estimated 2 models: a model that only included smoking status and no time-varying covariates and a model that adjusted for time-varying covariates.

Fixed-effects logistic regression models require that outcomes change within persons,[31] thereby reducing the sample to only individuals who experienced change in SUD recovery over the current study period (eg, smoking status could remain stable or change, but the binary measure of SUD recovery status was required to change in order to assess within-person change in the outcome). Consequently, the current study strictly focused on individuals with a history of SUD who experienced a change in SUD recovery over the study period (N = 2652 adults, with 9088 observations). Full-sample and replicate weights were used to account for the complex sample design, nonresponse, and attrition over time.

Since our primary research question did not address whether smoking status change preceded SUD recovery status change, we did not account for contemporaneous effects in primary analyses.[42,45] Smoking and recovery status were measured within the same 12-month period, and our primary research question addressed whether individuals had higher odds of recovery in years they did not smoke, accounting for all between-person differences. However, we conducted 2 sensitivity analyses. First, we tested whether there were differences in results after accounting for contemporaneous effects by lagging the SUD recovery outcome and main smoking predictor by 1 wave in dynamic panel data models.[42,45] The sample size for these analyses was reduced because participants needed to have changed SUD recovery status in 2 consecutive waves. Second, we tested the robustness of results by assessing the additional nationally representative cohort generated at W4. Data for the second cohort were gathered at intervals that spanned longer than 1 year, and they experienced the COVID-19 pandemic; consequently, assessing this additional cohort was not a primary analysis, since it did not test year-to-year change and the cohort could have been affected by the pandemic. There were also minor differences in available measures across W1 and W4 cohorts, which are described in eMethods 3 in Supplement 1.

Results

Descriptive Results

A total of 2652 individuals with 9088 observations were assessed, among whom 41.9% of participants (95% CI, 39.4%-44.4%) were female, and mean age was 39.4 years (95% CI, 38.7-40.3). By self-reported race and ethnicity, 17.0% of participants (95% CI, 15.3%-18.9%) were Hispanic, 13.9% (95% CI, 12.2%-15.6%) were non-Hispanic Black, 63.1% (95% CI, 60.4%-65.7%) were non-Hispanic White, and 6.0% (95% CI, 4.9%-7.4%) were another non-Hispanic race (Asian, Native American/Alaska Native, Native Hawaiian/Other Pacific Islander, more than 1 race).

Across the study period, being in SUD recovery vs not was nearly equal across observations (48.4%; 95% CI, 47.3%-49.4% vs 51.6%; 95% CI, 50.6%-52.7%, respectively). Current smoking was the most common smoking status (47.2%; 95% CI, 44.6%-49.8%), followed by former smoking (44.3%; 95% CI, 41.7%-46.9%) and never smoking (8.5%; 95% CI, 6.6%-10.9%). All other time-varying descriptive results are reported in **Table 1**.

Table 1. Weighted Estimates for Analytic Sample Across Wave 1 (2013/2014) to Wave 4 (2016/2018) of the PATH (Population Assessment of Tobacco and Health) Study[a]

Variable	Weighted % (95% CI)	Unweighted No.
Recovery status		
In recovery	48.4 (47.3-49.4)	4323
Current SUD or returned to use	51.6 (50.6-52.7)	4765
Current smoking status		
Currently smokes	47.2 (44.6-49.8)	5302
Never has smoked	8.5 (6.6-10.9)	520
Formerly smoked	44.3 (41.7-46.9)	3266
PROMIS Mental Health scale (range: 20-70), mean score (95% CI)	47.4 (46.9-47.8)	NA
Educational attainment (range: 1-4), mean score (95% CI)[b]	2.5 (2.4-2.6)	NA
Past-year physician visit		
Yes	71.2 (69.6-72.7)	6231
No	28.8 (27.3-30.4)	2857
Past-year emergency department visit		
Yes	31.3 (29.8-33.0)	3033
No	68.7 (67.0-70.2)	6055
Past-year medication use to help quit smoking		
Yes	2.4 (1.9-2.9)	255
No	97.6 (97.1-98.1)	8833
Urban or rural residence		
Rural	20.8 (17.4-24.6)	1936
Urban	34.3 (30.4-38.4)	3353
Suburban	35.1 (30.9-39.5)	2809
Town	9.9 (7.6-12.8)	990

Abbreviations: NA, not applicable; SUD, substance use disorder.

[a] 2652 Individuals with 9088 observations. Replicate weights were used in all analyses.

[b] 1 Indicates <high school or GED, 2 indicates high school graduate, 3 indicates some college or associate degree, and 4 indicates bachelor degree or higher.

Fixed-Effects Logistic Regression Results

Regression results in **Table 2** showed that within-person change from current to former smoking was significantly and positively associated with being in SUD recovery. Year-to-year, within-person change to former cigarette use was associated with a 42% increase in the odds of being in recovery (odds ratio [OR], 1.42; 95% CI, 1.18-1.71; *P* < .001), accounting for all between-person differences. This association was reduced after adjusting for time-varying covariates but remained strong and statistically significant (adjusted OR, 1.30; 95% CI, 1.07-1.57; *P* = .009). There were statistically significant associations for time and mental health, indicating a positive trend in recovery over time (adjusted OR, 1.11; 95% CI, 1.05-1.17; *P* < .001) and a positive within-person association between improvements in mental health and recovery (adjusted OR, 1.04; 95% CI, 1.03-1.06; *P* < .001).

Additional models that removed the never-smoking category were examined. All results for all analyses remained identical for the transition from current to former smoking. The main results are based on the larger sample size that retained the never-smoking category.

Sensitivity Analyses

eTable 1 in Supplement 1 reports results for dynamic panel data models that assessed within-person change but also lagged the recovery outcome and smoking predictor by 1 wave (4585 observations, 1686 individuals). The positive association between within-person change from current to former smoking and being in SUD recovery remained statistically significant and increased in magnitude in these sensitivity analyses (OR, 1.46; 95% CI, 1.03-2.07; *P* = .03). The association also remained statistically significant after accounting for time-varying covariates (adjusted OR, 1.43; 95% CI, 1.00-2.05; *P* = .04).

eTable 2 in Supplement 1 reports results for the sensitivity analyses that assessed the W4 cohort (11 605 observations, 3340 individuals). The positive association between within-person change from current to former smoking and being in SUD recovery remained statistically significant in these sensitivity analyses (OR, 1.70; 95% CI, 1.40-2.05; *P* < .001). This association remained positive and statistically significant after adjusting for time-varying covariates (adjusted OR, 1.37; 95% CI, 1.13-1.66, *P* = .002).

Discussion

This study's finding that smoking cessation was associated with recovery from nontobacco SUDs can be used to help justify

Table 2. Weighted Fixed-Effects Logistic Regression Results for Substance Use Disorder Recovery and Within-Person Associations With Cigarette Smoking From Wave 1 (2013) to Wave 4 (2016) of the PATH (Population Assessment of Tobacco and Health) Study[a]

Variable	Model 1 OR (95% CI)	Model 1 P value	Model 2 OR (95% CI)	Model 2 P value
Current smoking status				
Currently smokes	1 [Reference]	NA	1 [Reference]	NA
Never has smoked	1.31 (0.31-5.55)	.71	1.72 (0.36-8.35)	.50
Formerly smoked	1.42 (1.18-1.71)	<.001	1.30 (1.07-1.57)	.009
Time-varying covariates				
Time (wave 1-wave 4)	NA	NA	1.11 (1.05-1.17)	<.0001
PROMIS Mental Health scale (range: 20-70)	NA	NA	1.04 (1.03-1.06)	<.0001
Educational attainment (range: 1-4)	NA	NA	0.89 (0.76-1.05)	.16
Past-year physician visit (1 = yes)	NA	NA	0.89 (0.73-1.07)	.22
Past-year emergency department visit (1 = yes)	NA	NA	0.86 (0.73-1.01)	.06
Past-year medication use to help quit smoking (1 = yes)	NA	NA	0.77 (0.51-1.15)	.19
Urban or rural residence				
Rural	NA	NA	1 [Reference]	NA
Urban	NA	NA	1.30 (0.87-1.93)	.20
Suburban	NA	NA	1.40 (0.92-2.12)	.11
Town	NA	NA	1.02 (0.69-1.52)	.90

Abbreviations: NA, not applicable; OR, odds ratio.

[a] 2652 Individuals with 9088 observations. Replicate weights were used in all analyses. Model 1 does not include time-varying covariates, while model 2 includes time-varying covariates.

incorporating smoking cessation treatment into virtually all SUD treatment. Using data from the nationally representative cohort included in the PATH Study, year-to-year transitions from current to former cigarette smoking were positively linked to SUD recovery. Moreover, this within-person change in smoking and its positive association with SUD recovery existed after accounting for any potential confounders across individuals and time-varying covariates that are linked to SUD and smoking, such as changes in mental health.

Data from the PATH Study allow results to be generalizable to the millions of US adults who experience current SUDs, and the methods used allowed for an accurate assessment of the smoking-recovery association by approximating experimental conditions that minimize confounders across individuals. This is critical because between-person confounders could influence smoking status, SUD recovery, and their association, but methods used in the current study removed any (measured or unmeasured) between-person confounders,[31] with potential examples including whether individuals had ever received SUD treatment in the past or the type of substance used at baseline. Previous research has been limited because studies on this topic have often used data from single treatment centers or single cessation trials,[24,25] and previous research using nationally representative samples were from studies using data that were at least 20 years old and did not use methods to help provide highly specific tests for the association with SUD recovery.[32]

This study's results also showed that the association between within-person changes in smoking and SUD recovery remained robust in sensitivity analyses. After considering changes in smoking that preceded changes in SUD status and after analyzing a second nationally representative cohort studied over a longer and later period, the transition from former to current smoking was still significantly associated with SUD recovery. In sum, this study's hypothesis, which stated that year-to-year change from current smoking to former smoking would be positively associated with SUD recovery on a given year net of between-person confounders, was supported in primary and sensitivity analyses.

These findings reinforce the importance of addressing tobacco use among individuals with an SUD, including not only those who are actively receiving treatment, but also the millions of adults with an SUD who do not seek treatment.[19,32] Future research and practice should test ways to implement tobacco treatment for patients within the health care system.[8,46-50] Population-based approaches to cessation should also continue to be tested to reach individuals with SUDs outside of the health care system, including targeted cessation strategies and approaches to increase access to care.[51-53] Population-based policies geared toward helping individuals decrease or quit smoking, such as consistent and robust tobacco taxes and programs designed to increase tobacco quit line utilization,[53,54] could potentially help individuals in their recovery process. Future research should also consider other tobacco or nicotine products, such as e-cigarettes, in the SUD recovery process, both in terms of their link to smoking cessation and cessation from those products.

Limitations

Limitations to the current study include no direct measure of SUD treatment or medications, such as anticraving prescriptions, but past-year medical visits and other potentially relevant medication use were accounted for. There could also be other time-varying variables that were not captured, and all measures were based on self-report data. Finally, abstinence was used as the measure of recovery, and results generalize only to this outcome. Future research could also consider taking a harm reduction approach by assessing how smoking is linked to other measures of recovery, such as reductions in substance use.

Conclusions

Cigarette smoking remains persistently high among individuals with a nontobacco SUD, despite declines in cigarette smoking among the US population.[6] Health care professionals and systems that treat SUDs are in an opportune position to address tobacco use,[8] but tobacco use is often untreated in health facilities that treat SUDs.[13,16] In this cohort study, smoking cessation was linked to better SUD recovery outcomes, and it could improve overall health among the millions of US adults with a current SUD. Results suggest that smoking cessation could be used as a way to assist recovery processes among adults with an SUD.

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Concept and design: Parks, Creamer, Kingsbury, Everard, Marshall, Kimmel, Compton.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Parks, Compton.
Critical review of the manuscript for important intellectual content: All authors.
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